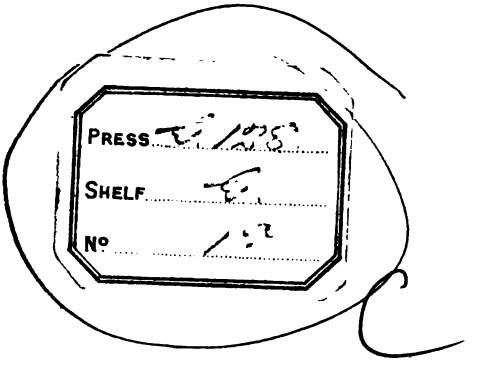

ON THE

FUNCTION OF RESPIRATION,

IN HEALTH AND IN DISEASE,

AND

MORE ESPECIALLY IN CHOLERA, TYPHUS, &c.

ALSO, ON THE

FORMATION OF ATMOSPHERIC AIR.

By RICHARD SAUMAREZ, Esq.

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1832.

TO SIR WILLIAM BLIZARD,

LATE PRESIDENT OF THE COLLEGE OF SURGEONS.

My Dear Sir William,

I beg you will accept this dissertation, as a mark of the sincere regard which I entertain for you, and as a proof, that although many years have elapsed since I have relinquished the practice of the Profession, the principles of which I had the good fortune to learn from you, nearly half a century ago, I nevertheless continue to pursue the science of it.

I am, my dear Sir William,

Yours most truly,

RICHARD SAUMAREZ.

Circus, Bath, 1832.

ON THE

FUNCTION OF RESPIRATION;

THE FORMATION OF ATMOSPHERIC AIR, &c.

CHAPTER I.

On the Function of Respiration.

It is not my present intention to inquire, whether the destructive disease which prevails in this country, as well as in France, has been imported by means of contagion from infected persons, or is a poison generated in the air,—whether it is to be considered, as an extreme case of typhus fever, to which are superadded symptoms of cholera, or whether it is the true Asiatic cholera itself.

Whatever diversity of opinion may exist in this respect, the fact is undeniable, that both diseases have symptoms common to each, and which would seem to identify the one with the other: these symptoms consist in extreme prostration of strength, as well as general languor which is felt, and more especially the purple colour, which the whole surface of the body exhibits.

In reading the various modes of treatment which have been adopted, one remedy has been overlooked and neglected, which appears to me, is more likely to be of use, if properly administered, than any other which has hitherto been employed.

In order to give the reader a clear apprehension of the subject, it is proper to observe, that a change is constantly taking place in every atom of matter of which animated beings are composed: after having received the participa-

tion of life, it is incessantly losing it, and verging from a living to a dying state. This important fact was satisfactorily ascertained, by a series of experiments made on pigs: —a number of these animals had a quantity of madder (a vegetable substance which manufacturers employ, to dye their stuffs of a red colour) mixed up with their food; several of these animals were killed at distant intervals from each other, and it was found that not only the soft but the hard parts, such as cartilages and bones, were completely changed into a red colour; the madder was then discontinued:—in the remaining pigs, which were killed in succession, the red particles had gradually disappeared, and in the course of seven years the whole of the madder had been absorbed, and all the parts had resumed their natural appearance. In order to prevent the evils which the retention of these dead particles within the system would necessarily produce, a set of vessels exist, called *lymphatic absorbent vessels*, whose design and end is to absorb these dead particles, and to remove them from the part in which the change has taken place.

These vessels arise with open mouths, from every part of the system, and may be considered to resemble in their action the suction of blood by a leech: they are smaller, in infancy and youth, than at the periods of manhood and of old age, and their action stronger in atonic and putrid diseases than in inflammatory, and more especially than in a state of health and of strength: they discharge the dead matter which they have absorbed, partly into the neighbouring veins, but more especially through the medium of the thoracic duct and left subclavian vein, to the right side of the heart, from whence it is conveyed to the lungs by the agency of the pulmonary artery. The pulmonary artery has two modes of termination, one of these is in innumerable continuous veins, which, uniting together, convey their contents to the left side of the heart; the other ter-

mination, in like manner, consists of numberless branches, which terminate, with open extremities, on the inner surface of the lungs, and exhale out of them the dead matter which had been deposited into them from the blood. It takes place at every pulsation of the heart, that is, sixty times in a minute, or once in every second of time: the quantity of dead matter which is accumulated in the air tubes, during four pulsations, is sufficiently great to create uneasiness, and cause the muscles of inspiration to contract; the cavity of the chest becomes thereby enlarged, and an unresisting medium within it is formed, which enables the air without, by its expansive force, to enter the mouth and windpipe, and to fill the cavities or cells into which this dead matter had been deposited. I am therefore led, in the next place, briefly to describe how this dead matter is expelled from the lungs by the agency of the inspired air.

The atmospheric air which is inspired, consists of two distinct gases, which are separable from each other by chemical means; in one hundred parts, seventy-nine parts consist of nitrogen and twenty-one of oxygen. In the ordinary state of health, the quantity of air which is admitted into the lungs during every inspiration, amounts from 14 to 17 cubic inches. It takes place fifteen times in a minute, when the pulse is 60; so that one respiration is necessary to take up the quantity of carbon which had been deposited during four circulations; although circulation and inspiration are not synchronous, they are consentaneous.

Whilst the air remains in the lungs, it is ascertained that the nitrogen has undergone no diminution in quantity nor alteration in quality. With the oxygen, it is far otherwise; instead of twenty-one parts preserving their identity, twelve and one-fifth only remain; nearly eight parts are found to have had their character entirely changed, and to have formed what is vulgarly called carbonic acid gas. The change which the oxygen has undergone—the new gas

which has been formed—is the result of the union which has taken place between the oxygen inspired and the dead matter excreted from the blood into the air tubes: this dead matter, having lost all alliance with the living system, becomes in the tubes, amenable to chemical laws, and undergoes in them the same changes as it would do out of them. By ascertaining the quantity of oxygen that was consumed in forming carbonic acid gas, Sir H. Davy, and more especially Messrs. Allen and Pepys, in a series of well-conducted and accurate experiments, published in the Philosophical Transactions, to which I must refer the reader, were able to estimate the precise quantity of these dead particles, which were deposited from the blood into the bronchia, and which amounted, in the course of twenty-four hours, supposing the excretion of them to be uniform during that period, to 5363 grains,—that is, to more than eleven ounces troy;* and the aggregate quantity of air which was received in a full grown person, amounts to 48,000 inches every hour, or 1,152,000 cubic inches in twenty-four, a quantity sufficient to fill seventy-nine hogsheads.

As soon as the carbon is acted upon by the oxygen which has been introduced into the lungs, the blood which flows from the pulmonary artery into the pulmonary veins, loses its dark modena colour, and becomes florid and red. The fact was most satisfactorily proved by Mr. Hunter, Dr. Goodwyn, and others. Mr. Hunter removed the sternum or breastbone of a dog, and exposed the heart and lungs: he then cut the windpipe, and introduced the nozzle of a pair of bellows into it. It was curious, Mr. H. observes, whilst the respiration was suspended in adjusting the instrument, to see the blood in the coronary arteries turning from red to black, and returning from black to red when

* According to this statement, the estimate which is made appears to be a moderate one,—that in the crowded assemblies of this gay and elegant city, an old woman is swallowed by each individual, in the course of the winter season.

air was forced into the lungs;—the experiment was repeated several times, and always with the same result. The improvements which it has thus undergone, is not by accession, but by deprivation;—not by the absorption of air, of caloric, or of any thing good from without, but by parting with every thing which is bad from within;—not by the blood absorbing air through the parietes or sides of the lungs, but by the air carrying away from the lungs the carbon they contain. The bronchia may therefore be considered as sewers,—the particles of oxygen, as the tools by which they are scoured and cleansed,—and the expansive force of the nitrogen, as the scavengers by which the dead matter is carried away.

The purification which the blood, in consequence, undergoes, appears to me to be accomplished by means somewhat similar to those we employ to clarify, by filtration, a foul bottle of port wine, through a strainer into a decanter. Whilst the strainer separates and sustains the lees and dregs, the portion of the wine which the decanter receives is found clarified; in like manner, as soon as the extremities of the pulmonary artery deposit the lees or carbon of the blood into the air tubes of the lungs, the residuary portion, which flows into the pulmonary veins, is florid and red, and is then fitted to answer the end for which it is designed; it is conveyed to the left side of the heart, from whence it is distributed to every part of the body for its nourishment and support. We have no fact to prove that either oxygen, caloric, or any other substance whatever, forces itself through the sides of the lungs, and enters the pulmonary veins; such a supposition is contrary to all the principles which govern the functions of the different organs of the system: every organ has a specific and determinate function to perform, and I defy any physiologist to point out to me, any one organ which performs, in the animal economy, the double and opposite office of excretion and of incretion.

The waste which the arterial blood undergoes of its purest parts, in the supply it affords in the function of secretion, as well as the deterioration it sustains, by residence in the vessels, have a constant tendency to change it from red to black; so the expulsion of the carbon by the air brings it back again from black to red. It is owing to the proper performance of this important function, on which depends the regularity in the temperature of the system, the vermilion colour of the lips, the florid complexion of the cheeks, as well as the healthy actions of the different parts.

Notwithstanding the immense quantity of air required by every individual for respiration, and that there is a surplusage of oxygen, in particular, for ordinary purposes, there is nevertheless a great deficiency of it on many extraordinary occasions. Whilst brutes invariably select situations best adapted to their individual condition,—man, on the contrary, is often found in the worst which can be conceived; he was created and destined to be a social, not a gregarious, animal; it did not, therefore, form a part in the scheme of Divine Providence, that multitudes of men and of women should congregate together like bees in a hive, in confined and unventilated apartments, much less that the air which is expired, loaded as it then is with a coalition of impurities the most nauseous and noxious that can be conceived, should constitute for the most part the only air which is allotted for each individual to respire. The evils which are in consequence produced, are manifested by every object to which the access of pure or oxygen air is necessary. It is proved by the blue and palid colour of the flame of the candles, and by extinction of fire in the grate,—by the sensation of suffocation which is felt, and the unpleasant odours which are excited on the olfactory sense,—by the dead matter which is conveyed to it in passing through the nostrils into the lungs,—by the arterial blood retaining all the properties of veinous,—purple and carbonized; instead of

the young preserving their florid beauty, their complexion becomes pallid and sallow, as if old age had been prematurely induced; whilst the sallow and purple complexion of the old, requires the artificial use of cosmetics, in order to conceal the ravages brought on in early life by folly and indiscretion.

The same consequences inevitably ensue to the labouring poor, from necessity, in crowded manufactories, as well as to prisoners confined in close prisons. The unhappy fate which befel our unfortunate countrymen, immured in the black hole in Calcutta, (a room eighteen feet square, having only two windows strongly barred, and so situated as to prevent any circulation of fresh air,) is too well known to be repeated in this place. I shall only mention, that out of one hundred and forty-six poor wretches, no more than twenty-three came out alive, the rest having died of suffocation during the night.—A more recent occurrence of the same nature, and proceeding from the same cause, happened during the late war. Thirty-four discharged soldiers were put on board a small cutter at Guernsey, to be landed at Southampton; soon after sailing, a gale of wind sprung up, which made it expedient that the men should go below, and the hatches be battened down. Shortly after, a violent tumult was heard, which the captain attributed to the effects of intoxication; a deadly silence then followed, which was ascribed to sleep, but alas! it was the sleep of death. Early in the morning, the cutter entered the Needles and got into smooth water; the captain then ordered the hatches to be opened, when a most offensive odour issued from the hold, and every man was found dead in it; shewing, by the bruises on their hands and bodies, the violent struggles which each had made to be liberated from his confinement. The captain, who was a good seaman and a humane man, but neither chemist or physiologist, was tried and acquitted. The same fatal consequences ensue when

nitrogen or hydrogen, carbonic acid, or any other gas, are inspired, which have no affinity to the dead matter which the air tubes of the lungs contain; instead of diluting and carrying it away, these gases only add to its activity, —they condense and compress it, and add to the load. It is in fact like carrying coals to Newcastle.

The cause of disease and of death which I have described, is common to the strong and healthy as well as to the weak and sickly; it altogether proceeds from a deficiency of oxygen gas in the atmosphere, which is necessary to carry away the ordinary quantity of carbon out of the air tubes, and to relieve the blood from it.

Disease the most aggravated, and death inevitable, often proceeds from an opposite cause, not from a deficiency in the ordinary quantity of oxygen gas in the atmosphere, but from an excess of carbon, which is generated within the system itself, owing to the rapid dissolution and decomposition which both solids and liquids in putrid diseases undergo, such as typhus fever, the plague, and more especially in aggravated cases of cholera, as they have existed in different parts of the world, and which the ordinary and usual quantity of oxygen gas in the atmosphere is unable to convert into a gaseous form and carry away.

Whilst the blood exists in this morbid condition, it is totally unapt and unfit to be acted upon by the glandular system in general, and the brain in particular. In addition to the extreme prostration of strength and weakness of circulation, common to atonic diseases;—in cholera, there is superadded to them, most violent involuntary actions of the voluntary muscles; *i.e.* cramps and spasms,—the liver secretes no bile,—the kidneys no urine,—the arterial blood continues to preserve all the properties of veinous, imparting to the skin a blue and purple colour. There is every reason to believe, from late experiments made on the blood of those who have died, that it is so loaded with carbon or

dead matter, that there is an excess of crassamentum and a deficiency of serum in it, insomuch that the drag is so great, the resistance to be moved is so strong, that the veins are scarcely able to propel it to the right side of the heart; and it is very probable, that in the most extreme cases, when sudden death takes place, that the whole mass of the blood does not reach the lungs, so that instead of an excess of carbon existing in the air tubes, there is found in them a deficiency of it.

Under circumstances such as these, the mode of treatment is very apparent; it must be a desirable object to feed and nourish the blood by administering animal juices in their most concentrated form; to excite the action of the heart and vascular system in general, by brandy and other warm cordials; to strengthen the solids, by quinine and other tonics; to soothe and tranquillize the nervous system, by large doses of opium; to increase the temperature of the skin, and to promote the excretion of carbon and of nitrogen from its surface, by hot vapour baths; and to discharge feculant matter from the intestines, by the agency of calomel.

However important these means may appear, they are only secondary and auxiliary; it is beginning the mode of treatment at the wrong end. Our first and paramount object ought to be, to relieve the lungs of the excess of carbon they contain, in order that the blood may become decarbonized. Experience has proved that, in health, oxygen gas is the only menstruum or solvent by which this purpose can be accomplished. As soon as it is inspired, a general glow over the whole system is felt, the pulse is raised, and the blood changes from a purple to a vermilion colour. Instead, however, of trusting in these putrid diseases to the small proportion of oxygen gas which the aggregate mass of the atmosphere contains, its quantity ought to be proportionally increased,—an artificial atmosphere

ought to be generated, in order that the patient may inhale it through an inhaler adapted for that special purpose;—it is to this particular object I wish to draw the attention of the profession. In mild cases, oxygen diluted with a small proportion of nitrogen, might be first employed; in the more aggravated cases, pure oxygen, or oxygen diluted with chlorine, should be tried,—and as a dernier resort, chlorine alone.

I do not flatter myself that by these means the ravages committed by this frightful disease will be stayed, or that they will prove generally successful; but I am persuaded, that unless the blood be decarbonized, and the lungs relieved of the carbon with which they are filled, death must as inevitably take place, as when air is totally excluded from them,—by submersion or strangulation, by mephitic inhalation, or by enclosing the patient under the exhausted receiver of an air pump.

The particles of dead matter which have been absorbed, are called lymph, whilst they continue in the lympathic vessels; carbon, when they are deposited in the blood and bronchia; and, finally, carbonic acid gas, after the carbon has been converted, by the oxygen of the atmosphere, into a gaseous state. It is very true, that carbonic acid gas, obtained from charcoal and other substances, and the gas which is expired from the lungs, possesses properties, which are common to both, that neither can support inflammation or animal respiration,—that both can decompose lime water, and turn vegetable blues to a red colour:—they nevertheless differ from each other in points the most essential. The experiments of Mons. Morveau, and other celebrated French chemists, have established the fact, in the most satisfactory manner, that tainted meat not only becomes fresh after it has been immersed in carbonic acid gas, but they have been able to preserve different kinds of meat immersed in it, for several years, without any appear-

ance of its having undergone any change, which could be called putrefactive. Neither is carbonic acid gas capable of turning arterial blood from a red vermilion to a purple or black colour. Dr. Goodwyn received red arterial blood, from the carotid artery of a sheep, into a phial filled with carbonic acid gas, and after agitating it for a considerable time, the blood retained its red colour.—With the air expired from the lungs, it is far otherwise: it is by the retention of carbon in the blood, that it becomes blackened, and its putrefaction accelerated.

The chemical change which the expired air produces out of the body, is equally extraordinary, whilst putrid meat is made fresh by exposure to the influence of carbonic acid gas:—fresh meat becomes immediately putrid by coming in contact with the air expired from the lungs. Every butcher and poulterer knows, that, with the exception of lightning and electricity, there is nothing that has so much power to taint and to putrify fresh meat, as the air which is expired by numbers of individuals in confined situations.

The difference which exists between carbonic acid gas and the gas expired from the lungs, is further proved, by the effect which each produces on different individuals, under different circumstances; whilst carbonic acid gas causes death by suffocation, without creating any fever, the gas expired from the lungs of persons labouring under scarlatina and measles, the plague and typhus, and perhaps the malignant or Indian cholera, causes disease and death, by first exciting a specific fever of the same nature as the source from whence it arises, not only on individuals, but on multitudes exposed to its influence, situated in distant parts from each other.*

* All epidemic diseases are contageous, but all contageous diseases are not epidemic. The itch, cancer, and a variety of others, are contageous, not epidemic; immediate contact being absolutely necessary to produce the disease, beyond which it does not extend. In epidemic diseases, the poison, by which the disease is produced, may exist in the air, but it nevertheless must be carried by it, and come into immediate contact with the system, before it can excite the same disease on other persons.

However disposed I may be to admit that the atoms of dead matter which, in a state of health, have been absorbed from cartilages and from bone, from tendon and from muscle, or from any other part of the system, are resolvable into the same elements, the variety of diseases, which are produced by different poisons, go decidedly to prove, that, although chemical analysis is unable to detect the difference, that they are not the same in their nature; that, however varied they may be in their properties and qualities, it must be admitted, when they subsist in the bronchia, in the lymphatics, or in the substance of the part from whence they are absorbed, they all consist of *dead* matter. Instead, therefore, of calling them *lymph* and *carbon*, these terms should be abandoned, and the generic term *azote* (from *azoe, non vita*, dead matter) ought to be given to them: instead of calling the vessels, by which this dead matter is absorbed, *lymphatics*, and the tubes into which it is deposited, *bronchia;* the lymphatics ought to be called *azotic absorbent vessels*, and the bronchia, *azotic tubes*. In like manner, instead of calling the vessels which absorb the aliment, and convey living matter into the blood, *lacteals*,* the term should be expunged, and they ought to be called *zoetic absorbent vessels* (from *zoe*, life). By these means, the nature of the things, as well as the functions of the organs subservient to their use, would be known by the names appropriated to each.

It is indeed to be deplored, that whilst the study of chemistry has been rendered comparatively easy, by aid of the new nomenclature which has been introduced,—so that compounds are known by the names which are given to them,—no attempt has been made to improve the nomenclature, in the higher and nobler science of physiology,

* The impropriety of the term will appear, when we reflect that although water is the only liquid which insects and fish, as well as birds, dilute the food which they swallow,—that the use of milk is confined to the class of mammalia in general, and that a vast proportion of the human race in particular, never take it, except it be in their infancy.

insomuch that it continues at this day, in the same barbarous state as it was during the dark ages of the world.

The errors, as I conceive them to be, which I have detailed, appear to proceed from the improper classification of matter in general which has been adopted; it has been classed under three different orders, or kingdoms,—into animal, vegetable, and mineral: a generalization such as this, appears to me highly objectionable, because extremely defective; whilst it marks a distinction between living and common matter, it makes none between common and dead, but both are merged into one. Neither does the mineral kingdom include that immense portion of matter which cannot be said to belong to it, which, instead of being immured within the bowels of the earth, subsists, for the most part, out of it: it not only excludes water and gaseous bodies in general, but the whole of the radiant and etherial matter which flows from the sun and the other parts of the planetary system. In order to correct this great omission, I shall class the matter of which the whole system of nature is composed, under three different orders,—of living matter, —of dead matter,—and, of common matter.

1.—By *living matter*, I comprehend the various orders of living beings with which the universe is replenished and adorned.

2.—By *dead matter*, I confine myself, altogether to the exuviæ of animals and of vegetables, as well as to the whole substance of which these systems are composed, after the actions of life have ceased, and the state exists which is known by the appellation of death. Matter such as this, if words are intended to express the thing signified, ought to be called *azote*.

3.—By *common matter*, on the contrary, I altogether exclude matter either living or dead, but confine the term, to the primitive or original elements of which the world is composed, or to the compounds formed out of them.—Mat-

ter, in fact, which either has never received the participation of life, or having received, has lost it, and been completely decomposed and resolved into a common state,—matter such as this, cannot, with any propriety, be called *azote*: in order that azote (dead matter) should exist, it must have previously subsisted in a living state. The nitrogen of the atmosphere ought not therefore to be called *azote*, as is generally done, more than oxygen, than water, or the primitive rocks of which the nucleus of the globe is composed. As the formation of the gases, which compose the atmosphere, has engaged the attention of philosophers, without any success, I hope I may be excused for giving my own views on this curious subject; and if I fail in the attempt, I shall only share the fate which my predecessors have experienced, and therefore claim for myself the same candour and indulgence which has been shown to them.

CHAPTER II.

On the means by which the Atmosphere is formed, and the Materials of which it is composed.

The chemical and mechanical changes which take place between different substances are regulated by the power of laws;—these laws are called laws of nature;—they have for their object, to regulate and controul the essential properties which different kinds of matter possess. Whilst *extension*, or the occupation of space, is common to all matter, so it is, that particular species possess specific and individual attributes, by which they are characterized. These attributes constitute what is called the nature of a body;—the nature of a body and the law by which it is governed, are totally separate and distinct from each other. The laws of nature did not create matter;—matter was created by the great Creator, the Lord of all, who is the Author and God

of nature. Whilst law is a rule of action, which directs and controuls the objects dependent on its operation, to certain determinate purposes or ends, its efficacy is manifested by the effects which are produced by them,—the effects which are produced do not constitute the law; they are the mere manifestations in the power of the law. Man, for example, was by nature created a free agent, having the option to follow his own inclinations: the moral law was, therefore, established in every nation, to regulate the freedom of the will, and to prevent the exercise of it from being injurious to the society of which he forms a part: the obedience of the individual to those rules of action, proves the power of the law,—the power of the law does not originate in the individual, it ends with him. Whilst the divine law implies the relation which man bears to God, the moral law implies the relation which man bears to man in society. If there were no individuals, there could be no relation, more than between something and nothing; the statute book,—the law and the prophets, would be of none effect.

The same relation exists between the laws of nature, to which matter is subservient:—these laws govern and controul the essential attributes which different species of common matter possess, with relation to the medium in which they are placed, and their efficacy is manifested by the change which matter is made to undergo. Laws of nature may therefore be justly said to consist of what the learned and venerable Hooker described them to be, "that which doth assign unto each thing the kind,—that which moderates the force and power,—that which doth appoint the form and manner of work; it is, in truth, one established and constant mode or process and fixed correspondence between cause and effect." We must not therefore contemplate the nature of matter in the abstract, isolated and unconnected with any thing, more than man, subsisting by

himself in the wilderness; we must endeavour to discover the properties which belong to it,—the relation which it bears to the medium by which it is surrounded, and with which it is in direct and immediate contact.

The chemical union which takes place between different bodies, is accomplished by what is called *attraction*; and as particular substances seem to possess a stronger tendency to unite together, to the exclusion of others, this tendency or preference, which is thus manifested, is called *chemical* affinity, or elective attraction. Whether the *nature* of this force is liquid or fluid, whether it be material or immaterial, as believed by many, is a metaphysical, not a physical, question. The law to which chemical attraction is amenable, was first discovered by Richter, of Vienna; it has been called by professor Thompson, of Glasgow, the law of definite proportions, and by the late celebrated Dr. Woollaston, the law of chemical equivalents. By aid of experiments, it has been ascertained, that in the formation of compound bodies, out of different elementary parts, the elements or atoms unite together in certain determinate proportions or ratios, according to the densities of each; so that the quantities of matter, contained within determinate bulks, can be measured and ascertained by their relative weight, as that of one part to one part, one part to two parts, one part to three parts, or even to four. It is consequently inferred, that every change in a compound thus formed, whether it be of addition or of diminution, is a precise multiple or divisor of such ratio; or, in other words, that simple bodies can never unite or separate,—never lay hold of, or let go, each other, in any other proportion than those I have mentioned. It is probably owing to the operation of this law, that the great variety which we behold between the properties of different bodies, composed of the same elements, is to be ascribed, and more especially between vapour and gas.

ON VAPORIZATION.

It would be a vain attempt, to enquire how much azotic gas has been generated and evolved, on the surface of the earth, from animal and vegetable excretion and decomposition, and expanded in the firmanent above it; the nature of the myriads of animalcules which float in it; the quantity of electric matter it contains, or the number of solar rays which flow from the sun and other parts of the solar system, and which pass through it. I shall confine myself, to the means by which the vapour and gases of the atmosphere are formed, and the materials of which they are composed. —The subject has engaged the attention of philosophers, from the earliest period to the present time. Halley, Saussure, and a multitude of celebrated men, conceived, that the process of vaporization and of gassification, was accomplished by the chemical affinity which exists between air and water, in a manner similar to the solution of sugar, or of salt, in water: air dissolving the water, as the water is known to dissolve the sugar: as water is the menstruum, by which the solution of the sugar is accomplished; so air is the menstruum, by which it is supposed water is vaporized.

However correct the views of these gentlemen may appear, it is evident that they began the investigation of the subject at the middle, not at the beginning; they ought to have decided the previous question,—the question as to the means by which air and vapour are formed, and the sources from whence they are derived.

Although caloric and other subordinate agents, may exist in the formation of atmospheric matter, it is, I am persuaded, to the chemical power of the solar rays, on the aqueous matter of the globe, to which the grand supply is to be ascribed. The immense quantity of water, which has been converted from a liquid to a vaporific state, from a given surface, has been estimated by some of our most

able philosophers. Dr. Halley calculated that the evaporation, that is to say, the change of water to a state of vapour, of the Mediterranean sea alone, amounted to 5280 millions of tons, a quantity sufficient to yield back all the water contained in the many rivers that flow into it. Dr. Watson, the former bishop of Llandaff, in a series of experiments, made with great judgment, ascertained that at a time, when there had been no rain for above a month,—when the ground was quite brown and parched,—the evaporation was not less than 1600 gallons, in twenty-four hours, per acre. I have the high authority of professor Leslie, to show, that if a pond for the supply of a navigable canal, exposes a surface equal to ten acres, he can ascertain, that if the atmometer, which he has invented, sinks a given number of points during the lapse of twenty-four hours, the quantity of water exhaled in that time, would be $\frac{8}{1200} \times 660 \times 66 \times 10$, or 2904 cubic feet, which corresponds to 81 tons in weight.*

There is no doubt that a great portion of this immense mass subsists in a vaporific, not in a gaseous state; it retains its humidity or moistness, and is easily separable from the solvent, by which it was vaporised,—by pressure,—by exposure to diminished temperature,—and by immediate contact with different substances to which it has affinity; hence it is that different salts and other substances deliquesce by the union which takes place between them; like a supersatured mixture of sugar and water, the particles adhere loosely, and therefore separate from each other easily. I shall therefore proceed to trace the progressive change which the same elements undergo, in consequence of the different proportions, in which they are combined together.

* It is not because combustion takes place when an electric spark is passed through oxygen and hydrogen gases, and the imponderable and combustible parts are separated from the ponderable and incombustible, that we are to conclude, that these gases are the elements of which all the water which exists is composed. The precipitation of water from these gases only shows that it is a constituent part of them. N.B. There is little or no hydrogen gas in the atmosphere.

ON THE FORMATION OF NITROGEN.

Whatever facility may exist in ascertaining the proportions between solids, liquids, and gases, by the relative weight of each, according to the law of definite proportions, such is the extreme subtlety of caloric, and more especially of the matter of light, that it is impossible to know the quantity of them, which form different compounds, by that measure. Caloric and light are altogether imponderable and destitute of gravity, gravitation, or weight; the law, therefore, of definite proportions in regard to them, is different from that which governs other bodies. Although I am not prepared to shew how many atoms of caloric or of light are necessary to unite with a given number of atoms of water, to form vapour, or nitrogen, it is fair however to presume, that it is not until that law has been justified and obeyed, atom to atom, and the point of saturation between the elements has been attained, that gassification can properly be said to have been accomplished. Water then loses all the properties which it formerly possessed; from a state of moistness and opacity it becomes transparent and dry, and from being immotive and inert, it acquires an expansive force, from a centre to the circumference, equally in every direction.

The chemical affinity which the elements possess, after the union has been accomplished, is so strong, the parts are so rivetted and united together, atom to atom, particle to particle,—the bond of union between them is so total and complete, that they keep themselves to themselves; they reject alliance with every thing, and therefore combine separately, I may almost say, with nothing. This gas is inodorous and insipid; it neither changes the colour of vegetables, to a blue or to a green; neither does it turn lime water into a milky white; neither is it decomposed by combustion or respiration, by fermentation or putrefaction.

Messrs. La Voisier and Morveau immersed different kinds of animal matters, in confined vessels, in this gas, for five or six years, without any putrefactive change having taken place. The most varied tests have been employed, by the most expert chemists, to decompose it, which have proved altogether fruitless; it has, on that account, been supposed to be a simple elementary body; so far, however, from this assertion being admissible, I conceive it to be more probable that the two elements, light and water, united together in different determinate proportions, form a *binary-unit* together,—binary, as far as relates to the two elements which enter into its composition, but a unit, insomuch as they always act together as one, and are inseparable from each other, as if they were one: and however paradoxical the term binary-unit may appear to some, I consider it as legitimate and appropriate, and in conformity to the nomenclature of chemistry of the present day, by which the names of compounds are derived from the elements out of which they are formed; I wish to expunge the common name which it bears, of *nitrogen*, and more especially that of *azote*, that is, dead matter, and substitute that of *photite* of water—of *photite* from *phos*,—*photos*, light, as the active agent, and water as the passive base, which is gassified by the solvent power of light; and I would call the watery vapour, which is formed by the united agency of light and caloric, and which is mechanically diffused in the *photite* of water (or nitrogen)—a *subphotite* of water.

I well know I shall be called upon for experiments, to prove the truth of my positions; such, however, is the imperfect state of the chemical art, even at this time, that, although the varied changes which the atmosphere undergoes, from a moist to a dry state, and from a dry to a moist one, go decidedly to show, that there subsists chemical agents, in the great laboratory of the firmament, by which the formation and decomposition of the different gases, of

which the atmosphere is composed, take place, none of our best chemists have been able to decompose the photite of water, or nitrogen. I am nevertheless persuaded, that if equal volumes of it were examined, the *quantity* would be very different, at different times; it would be found that there subsists greater numbers of gaseous particles of it in a dry, than in a moist day; the proof of which is manifested, by the increased intensity and velocity with which the pulsations of the air are propagated to the auditory nerves, as well as by the elevation which the mercury in the torricellian tube is found to undergo; and, on the contrary, the diminution of the quantity of air in the atmosphere, in a moist and wet, more than in a dry day, is proved in the retardation and in the propagation of sound, as well as by the depression which the mercury in the torricellian tube sustains.

From the deprivation of all chemical power in the *photite* of water, it is evident that the whole of its influence must be of a mechanical kind, by virtue of the expansivity which it inherently possesses, but that it cannot operate any chemical change on bodies exposed to its action. I am therefore led, in the next place, to detail the remaining portion of the atmosphere, known by the name of *oxygen gas*, which consists of one-fifth of the whole mass: the view which I have taken of the means by which it is produced, the sources from whence it is derived; the cause why it possesses chemical properties, of which the *photite* of water is destitute; as well as the immense waste which it undergoes, is perpetually restored.

ON THE FORMATION OF OXYGEN GAS.

The reproduction of this important matter has been ascribed to the function of vegetation, as well as to the chemical action which takes place between particular substances from which it is disengaged, more especially the

red calx of lead, and the black calx of manganeze; an examination into these means will shew that they are totally insufficient for the purpose. In order to reduce the lead and the manganeze from a metallic to a calcified state, it is necessary to subject them to the action, not of atmospheric heat only, but of the most ardent fires—so that the quantity of oxygen which is abstracted from the air, in producing the combustion, is much greater than what is absorbed by the metal, during the change which it undergoes. So far, therefore, from an increased quantity of oxygen gas being produced, there is a deficiency of it. This mode of supply must consequently be given up.

Neither can the formation of oxygen gas be ascribed to the renovating influence of vegetation. Dr. Priestly, some forty years ago, flattered himself he had discovered the mighty secret; he proclaimed it to the world, with as much display as if he had found out the philosopher's stone. Dr. P. amused himself in making experiments on the leaves of mint, of mustard, and of other plants; and having ascertained, that when these vegetables were exposed to the solar rays, they corrected bad air, by evolving pure or vital air, as he then called oxygen gas; he therefore concluded, that vegetable action was the source and immediate cause of oxygenous formation.

These experiments, however specious and plausible they may appear to superficial observers, were soon proved to be altogether fallacious; it is true they revealed the truth, but not "the whole truth, and nothing but the truth."—Dr. Ingenhotz, a man of strong intellect and power of observation, proved, by a series of well-conducted experiments, it was owing to the solar rays, more than to vegetable action, that the formation of oxygen gas was to be ascribed; he found, that although it was very true, when vegetables were exposed to the solar rays, they had the power of correcting impure air; but when they were placed in the dark

during the day, and more especially at night, the air became contaminated by the exhalations which they evolved. Dr. Ingenhotz put a mustard plant under a glass receiver, containing atmospheric air; its stem was cut off to the same level as the mouth of the receiver; the vessel was then inverted into an earthen pan, to keep the plant alive, and the whole apparatus placed in a room, where it remained the whole night: on examining the air, in the morning, it was found so much contaminated that it extinguished the flame of a wax taper; but, on exposing the apparatus to the rays of the sun, for a quarter of an hour, the air was found somewhat corrected, and after the lapse of an hour and a half, it was found so much improved, that by the test of nitrous air, it appeared much better than common atmospheric air.

Much less can the formation of oxygen gas be ascribed to the excretory matter from the skin or lungs of animals, during the processes of perspiration and respiration. The airs which are then evolved consist, for the most part, of what chemists call carbonic acid gas, and azote or nitrogen. —Mr. Abernethy, by experiments which he made on himself, whilst in a healthy state, ascertained that the cutaneous exhalation alone amounted to two pounds, and of air nearly three gallons, in the course of twenty-four hours. If a mass such as this can be produced by a man in a state of health, during a period so short, how immense must the quantity of foul air actually be, which is evolved by animals in general and the human race in particular, more especially in a state of disease, as well as other bodies during the processes of fermentation and putrefaction.

The question, therefore, becomes one of great importance, to know the means which exist in the system of nature, by which the enormous and incessant waste, which the oxygen of the atmosphere sustains, by the function of respiration of animals,—by the combustion of combustibles,

and the chemical compounds which it forms with different substances, becomes restored with the greatest rapidity, not only in quantity but in quality also, in different parts of the world, however remote from each other; so that the air of crowded cities,—of low damp situations,—of confined manufactories, and putrid hospitals, has been found, by chemical analysis, to contain oxygen air, the same in quantity and quality, as in an open champaign country. If it were not for the high authorites by which the fact has been ascertained, I should disbelieve it. Sir Humphrey Davy found air brought in bottles from the river Senegal, in Africa, possessed, by chemical analysis, the same proportion of oxygen as the air of Hammersmith. Bertholet ascertained that the air of Egypt was the same as that of France;—Demarti proved the same in Spain;—Count Seguin analysed the air, in the wards of hospitals, which had been carefully shut up for twelve hours previous to the experiment; although this air had acquired an unsupportable fœtid odour, he nevertheless found it almost as pure as atmospheric air;—and, finally, Gay Lusac proved, by experiments, that the different strata of the atmosphere contained the same gases, in the same relative proportions; he ascended in a balloon, to the elevation of 21,735 toises above the level of the sea; he filled a glass bottle with air, which was found to contain rather more oxygen than the air nearer the surface of the earth, 21-49 parts in 100, but in regard to its properties, they were the same.

It is to the sun to which we must look for the formation of this important matter; there subsists an absolute physical necessity, that the rays which emanate from it should penetrate the nitrogen of the atmosphere, as they flow to the surface of the globe. The affinity which subsists between the separate elements of which the nitrogen is composed,—the saturation between them is so complete, that they form one united whole; instead, therefore, of those

rays entering into chemical union with it, twenty per cent of them are left suspended in it, *i. e.* twenty parts in one hundred, in a state of mechanical diffusion; insomuch that whilst the nitrogen of the atmosphere is supersaturated with them, the remainder passes through in a radiant form.

It is this hyperquantity of solar matter which the nitrogen receives, and which it has the capacity to sustain, which I presume with great deference to believe, constitutes the element known by the name of *oxygen*: so that nitrogen may be considered as the recipient or matrix in which it is contained. Instead of continuing, like nitrogen, in a state of unity, neither changing the qualities of the bodies by which it is surrounded, nor changed by them,—the solar matter, the simple element which constitutes the oxygenous principle, subsists, like watery vapour in nitrogen, loosely in it, and is at liberty to unite with every substance, to which it has affinity;—it is active with every thing, and passive with nothing;—it becomes the operative and combinative principle, by whose energy the different chemical changes we behold different bodies undergo, are principally to be ascribed.

It is the principle of oxydation in metals,—of acidulation in vegetables,—of respiration in animals—of inflammation in combustibles, and is the most arid substance in nature. It answers to what the late Dr. Murray very justly says of it, "that the affinities of oxygen are more extensive—its combinations more numerous and its actions more energetic, than any other chemical agent; so that the developement of its energies forms the principal objects of chemical science." Instead, therefore, of continuing the name of oxygen, I would change it, and call it the *hyperphotite of water.*

The mechanical property which these gases possess, identify their generic character, by which they are distinguished from every other substance: instead of falling like

dense bodies, by their weight, in a line perpendicular to the horizontal line,—instead of remaining bent, like flexible bodies, without the power of unbending themselves, when an external force has been exerted at both extremities, or returning to their original situations, like elastic bodies, after the external force has been removed; gaseous bodies possess the essential and inherent power of expanding, from a centre to the circumference, equally in every direction; not like flexible and elastic bodies, by the agency of an external force: the developement of this expansive attribute is more especially manifested when all external resistance is taken away.*

Whilst the nature of air is to expand equally in every direction, the law, to which it is subjected, having relation to the medium in which it is placed, directs its expansion where the least resistance exists; hence it is, that owing to the unresisting state of the upper regions, the whole column of the atmosphere progressively decreases in density, in consequence of increased dilatation. Whilst the expansion of the upper strata takes place, a progressive diminution of pressure from the top to the bottom, throughout the whole atmospheric column, will be the inevitable consequence, in a manner similar to a small portion of air enclosed in a large bladder under the exhausted receiver of an air pump, insomuch that the pressure of the air, near the surface of the earth, is less in degree sideways and downward than it is perpendicularly upwards;—so far from the lower strata of the atmosphere subsisting in a state of condensation from superincumbent compression, the upper strata are in a comparative state of dilatation from a diminution of superincumbent resistance. Instead of the lower strata supporting the upper, the upper strata are rather pressed up by the expansive force of the lower; instead of a progres-

* Having investigated these subjects at large, in a work which I have published, it is unnecessary for me to dwell on them in this place.

sive condensing of the whole mass from top to bottom, there is, on the contrary, a general rising of the whole mass from the bottom towards the top.

If decomposing causes, therefore, did not exist, every substance which had been converted on the earth's surface, from a solid or liquid state to a gaseous one, would rise and fill the upper regions, insomuch that the surface of our globe would be left in a state of perfect dessication.

Notwithstanding these obvious truths, as they appear to me, it has been universally believed, from the time of Galileo, and especially of his pupil Torricelli, to the present day, that the upper strata of the atmosphere press upon the lower, like so many bags of wool piled upon each other, so that the lower strata carry the weight of the upper, and that the weight of the atmospheric column, at the level of the sea, amounts to 15 or 16 pounds to every square inch of surface, and as there are 144 square inches, to every square foot, it must consequently sustain a pressure of weight upon it amounting to 2304 lb.;—supposing, therefore, that a man, in an erect posture, covers a space commensurate to a square of 18 inches, the weight of atmosphere upon him is equal to 5184 lb.; but when in a recumbent position, when the surface of his body is supposed to be equal to a square of eight feet, it is very justly affirmed (if the positions were true from whence these conclusions are drawn) that he must sustain the enormous weight of seven tons for his ordinary load.

From the operation of weight in the atmospheric column, it is believed, that a bladder with which an exhausted cylinder may have been covered, will burst; that a receiver is fixed to the pump-plate; that water is forced up an exhausted pump as high as 34 feet, and mercury in an exhausted tube to the elevation of 28 or 30 inches. The most superficial knowledge of the subject would teach any one, that if two barometers, (falsely so called) are placed near each other,

and when the mercury in both is at the same elevation; if one of them has a glass receiver put over it, within which the external column of air is totally excluded, whilst the other is exposed to the whole of it, no alteration whatever will take place between them,—the mercury in both will continue the same; if weight of air, therefore, is the cause of the elevation of the mercury, the weight of a column of air, 42 inches high, which is enclosed under the glass, produces the same effect as the weight of a column of air 42 miles high, above it, *i. e.* the lesser weight produces the same effect as the greater, which is contradictory and absurd.

Much less is it true that the density of the lower strata of the atmosphere is caused by the weight of those above them. The density and the resistance of the particles below being, not only equal, but greater than those above them, no effect is produced, because equal forces which counterbalance each other, become neutralized, inoperative, and inert; much less can gravity or weight be ascribed to caloric or fire, and especially to the matter of light.

These errors appear to me to proceed from the physical doctrines advanced by Sir Isaac Newton, the most profound mathematician perhaps that ever existed. It is greatly to be regretted, that instead of supposing there exists an essential difference in different kinds of matter, between solid and fluid—opaque and rare—active and passive,—and adapting particular laws to each, he established one general law for the government of the whole,—the law of universal gravitation; and because he saw a rotten apple fall from a tree in his garden, he was led to conclude that the motions of the heavenly bodies were governed by the same law. Had that tree been immersed in water, and not in air, instead of the apples falling to the ground, they would have risen to the surface of the water; and it is probable that we should not at this day have to complain of the universal conclusions which have been deduced from one solitary fact, much less

that an effect such as this would have laid the foundation of this stupendous and ponderous system.

According to this system of physics, it is assumed as a principle, that no bodies really light are to be found, but that all are absolutely heavy; he called *relative* or *specific* gravity, common or vulgar; but absolute gravity was real and true; it does not depend upon the relation which exists between the density of one mass of matter and the rarity of the medium in which that mass is placed,—real or true gravity is altogether independent of it,—that, as all bodies gravitate towards the earth, so does the earth again gravitate towards all bodies, insomuch that the attraction of gravitation is supposed to be mutual and equal. It was from a process of reasoning such as this, that Sir Isaac Newton concluded, that the sun, from its relative magnitude to the other parts of the heavenly bodies, formed the attracting centre of the planetary system, and that the law to which this force was subject, was directly as the mass and inversely as the square of the distances.

If the sun could produce an attracting influence on bodies that are situated at the remotest distances, as the planets Saturn and Uranus,—if it could draw them to its centre, how much stronger would that power be exerted on bodies nearer to it? On the luminous atmosphere, for example, by which Herschel supposed the sun to be surrounded, and more especially on the solar rays themselves, if they are derived from the body of the sun itself. While the extreme tenuity of their nature, as well as the wonderful powers of motion which they possess, prove that they are not solid, ponderable or inert, as this illustrious mathematician supposed all matter to be; it nevertheless cannot be denied, that from their proximity to the attracting centre of the sun, they would be inevitably attracted by it, would be retained within it, without issuing out of it, so that the universe at large would be involved in absolute and utter darkness.

How much greater would these consequences take place if the sun was a globe of fire, as Sir Isaac Newton supposed;—he was so strongly impressed in the belief of its fiery nature, he calculated that the comet of 1680, during its perihelion to the sun, must have been two thousand times hotter than the heat of red-hot iron, and would have taken fifty thousand years to cool. A furnace such as this, would have evaporated and calcified every particle of matter belonging to it. I would however ask any one, from the repulsive power which fire is known to possess, what must be its effect upon all bodies exposed to its power, and whether it be reasonable to suppose, that fire, which in all its essential properties, is known to be the most repulsive body of which we have any knowledge, can be an attracting one, without coming to the absurdity of making the force of repulsion the depository of attraction.

It is however but justice to the memory of this great man, to say, that long before his death, he indignantly discarded the physical doctrines which he had advanced in his *Principia;* and he confirmed this recantation near twenty years after, in the second edition of his book on optics; he not only disclaimed the idea that the rotation of the planets on their axis, or their motion in projection, proceeded from a gravitating cause; he, on the contrary, expressly declares, that these motions were caused "*by the Divine Arm, to impress them,*" &c. The legitimate conclusion, therefore, is, that the third motion, namely, the centrepetal, or centre-seeking motion, is caused by the Divine Arm also, that is, by the providential interposition of the Almighty. The illustrious author of this doctrine has not left this conclusion to be made by his readers; he has drawn it himself; it is contained in the correspondence which took place between him and the celebrated Dr. Bentley, and is published in the *Principia*, where it will be seen, that he indignantly discarded the idea that one body could act upon another at a distance, without mutual contact or intervening medium.

It is important to note the dates, not only when the *Principia* were published, but also when the correspondence with Bentley was begun. The *Principia* were published in 1687: the third letter to Bentley was dated 1693. In that letter, Sir Isaac says,—"it is inconceivable that inanimate brute matter should, without the "mediation of something else, which is not material, operate upon and affect other matter, without mutual contact, "as it must do, if gravitation be essential and inherent in "it; and this is one reason why I desired you would not "ascribe innate gravity to me. *That gravity should be "innate, inherent, and essential to matter, so that one body "may act upon another at a distance, through a vacuum, without the mediation of any thing else, by and through which "their action and force may be conveyed from one to another, "is to me so great an absurdity, that I believe no man who "has, in philosophical matters, a competent faculty of thinking, "can ever fall into.*" I would therefore appeal, in the language of Newton, to any man who has the competent faculty of thinking, whether any language can be more explicit and strong to shew that matter cannot act where it is not upon matter at a distance, through a vacuum.*

He even went beyond this. In order, as it would seem, to relieve his mind from the error which he at first had committed, he took the deliberate opportunity, in 1714, twenty years after the publication of the *Principia*, when the second edition of his book on optics was published, to propose a question, for the purpose of accounting, by a ma-

* It is curious to notice with what care the Newtonians have kept back this information. The biographical account of Newton has been lately published by Dr. Brewster;—it is written with all the talent that was to be expected from an author so highly gifted. It is nevertheless a matter of reproach, that whilst the warmest commendations are passed on Newton, for the matter which those letters contained, and that copious extracts are given out of them, every syllable is omitted of the subject which I have stated, and which is the most important of the whole. It is however satisfactory for me, to have discovered, that the recantation, which I have noticed, was published by the learned author of "*Ancient Metaphysics*," as well as by the Rev. Dr. Crombie, in a work on natural theology, in which the doctrines of the atheists and materialists are not only examined, but refuted and exposed: the existence of a First Cause, as well as his providential care, in the government of the universe, firmly established. This work is written with logical precision, with great perspicuity of language and profound thought.

terial cause, for the gravitation of the planets towards the sun, and which he ascribes to the agency of an *elastic æther* or medium, which "he supposed, pervades all space. "This medium, he believed to be much rarer within the "dense bodies of the sun and stars,—planets and comets, "than in the empty central spaces within them; so that "it grows more and more dense at greater distances from "them. All bodies, therefore, (he adds) naturally tend "towards each other by excess of pressure."

The opinions which he entertained, in the existence and office of this æther, were not only an actual denial in the existence of a vacuum, but of the gravitating motion of the planets, by virtue of the quantity of matter they contained: it was, in truth, a recantation total and complete of the physical doctrine which he had advanced; so that the Newtonian system ought to be considered as a mathematical system of physics,—not a system of physics, founded on the nature and properties of the matter to which it refers.

It is probably owing to this cause that a proper distinction has not been made between *creations* and *formations*; whilst *formations* are produced by secondary causes, either chemical or mechanical,—by the action of matter upon matter, —by direct and immediate contact, and are subservient to the laws of nature; *creations*, on the contrary, are independent of secondary causes,—they derive their efficacy from the energy of the first cause, who created them by his command, and who governs them by his Providence. Instead, therefore, of supposing that the planets perform certain revolutions in certain times, (although they correspond with Kepler's law of equal areas in equal times,) by any material agency, I, on the contrary, refer these motions to the power and providential interposition alone of the Almighty Creator.

S. Barbet, Printer, Guernsey.